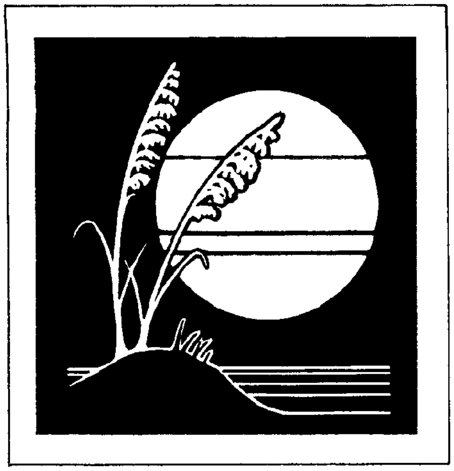

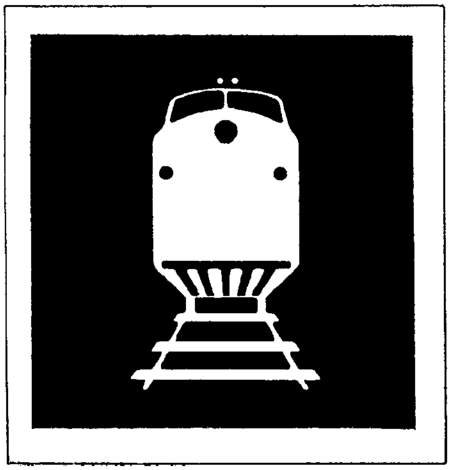

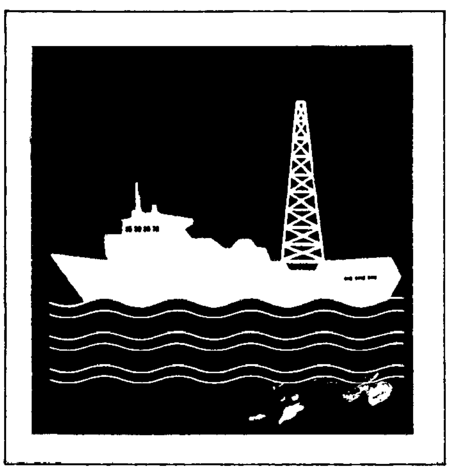

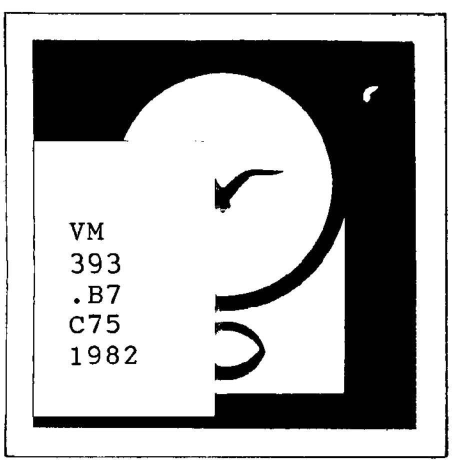

Coastal Energy Transportation Study
Phase III, Volume 4
The Potential for Wide-Beam Shallow-Draft Ships to Serve Coal and Other Bulk Commodity Terminals Along the Cape Fear

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AUGUST 1982

North Carolina
Coastal Energy Impact Program
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COASTAL ENERGY TRANSPORTATION STUDY
PHASE III, VOLUME 4

The Potential for Wide-Beam, Shallow-Draft Ships to Serve Coal and Other Bulk Commodity Terminals along the Cape Fear River

by
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August 1982

PREFACE

This report is the last of four reports from the third phase of a three-phase study funded by the Coastal Energy Impact Program and conducted by the UNC Institute for Transportation Research and Education. Phase I of this study, conducted in 1980, identified and documented the transportation needs necessary to support a group of energy projects proposed for the coastal area of North Carolina. Phase II of this study, conducted from September 1980 to August 1981, had two distinct parts:

1. An assessment of impacts of the Outer Continental Shelf (OCS) oil and gas exploration and production activity with emphasis in the transportation requirements and alternative locations for on-shore support base(s) in North Carolina, and

2. An assessment of impacts of coal exports from North Carolina with emphasis on the transportation requirements of alternative locations and capacities of coal terminals.

Phase III of the Coastal Energy Transportation Study, conducted from September 1981 to August 1982, is an assessment of more specific technologies for handling coal and other commodities at marine terminals, the competing impacts of energy transport and development on the recreational and other industrial sectors of the economy, and a more detailed analysis of rail transportation through eastern North Carolina to the State's port cities of Wilmington and Morehead City. The four reports prepared under Phase III are entitled:

1. Volume 1: Alternative Technologies for Transporting and Handling Export Coal, by Paul D. Cribbins and R. Daniel Latta (already printed as CEIP Report #12).

2. Volume 2: Projected Demands on Coastal Area Transportation Systems Resulting from Recreational and Industrial Development, by Paul D. Tschetter, et al.

3. Volume 3: Impacts of Increased Rail Traffic on Communities in Coastal North Carolina, by John R. Stone, et al.

4. Volume 4: The Potential for Wide-Beam, Shallow-Draft Ships to Serve Coal and Other Bulk Commodity Terminals along the Cape Fear River, by Paul D. Cribbins.

Separate reports were prepared documenting the results of Phase I and Phase II. These previously published reports are entitled:

1. "Coastal Energy Transportation Study: Phase I, An Analysis of Transportation Needs to Support Major Energy Projects in North Carolina's Coastal Zone" (December 1980, CEIP Report No. 1);

2. "Coastal Energy Transportation Study: Phase II Volume 1, A Study of OCS Onshore Support Bases and Coal Export Terminals" (August 1981, CEIP Report No. 2);

3. Coastal Energy Transportation Study: Phase II Volume 2, An Assessment of Potential Impacts of Energy-Related Transportation Developments on North Carolina's Coastal Zone" (January 1982. CEIP Report No. 3); and

4. "Coastal Energy Transportation Study: Phase II Volume 3, An Analysis of State and Federal Policies Affecting Major Energy Projects in North Carolina's Coastal Zone" (August 1981, CEIP Report No. 4).

All of these reports are available from the Office of Coastal Management, North Carolina Department of Natural Resources and Community Development.

The scheduling of the various tasks for each phase of the study was designed to permit the study team to complete key activities in advance of certain critical dates. For example, many of the tasks related to OCS activity in Phase II were completed so that state, regional, and local decision-makers involved in the OCS program would have output prior to August 1981, the scheduled date for OCS Lease Sale #56 by the Bureau of Land Management.

The movement of export coal shipments through North Carolina is now underway. The contract with Alla-Ohio Coal Company to ship three million tons annually through the State Ports Authority (SPA) facilities in Morehead City was announced in October 1980; and the first shipment of export steam coal left Morehead City for Holland on May 13, 1981. Although the situation regarding the development of energy projects is constantly changing, this report is based onthe most up-to-date information available at the time of printing.

The purpose of the Coastal Energy Transportation Study is to provide state and local governmental officials and policy-makers with sufficient background data and scenario analysis to permit informed, rational decision-making for energy- and transportation-related development activities affecting the state in general and the coastal zone specifically. The eight reports of this study (Phase I; Phase II Volumes 1, 2, and 3; and Phase III Volumes 1, 2, 3 and 4) are not to be construed as either engineering analyses or as economic/feasibility studies sufficient by themselves to justify (or reject) specific alternatives of any development activity. Instead, the reports should be used as tools to effect better management of the state's resources and activities.

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ABSTRACT

Many U.S. ports face the dilemma of deepening harbors and approach channels to accomodate deep draft vessels, especially supertankers and large dry bulk carriers. In most locations, channel dredging simply is not feasible because of the huge capital outlays required or because of the environmental problems created. An option to dredging that is beginning to receive serious consideration embraces the design and operation of a fleet of bulk carriers whose wider beam provides an increase in deadweight tonnage over "conventional" vessels with the same draft. For the 40- to 45-foot draft restriction encountered in most U.S. Atlantic coast ports, a 40 to 60 percent increase can be obtained by accepting reasonable departures from "conventional" vessel proportions.

A technical assessment previously prepared for the U.S. Maritime Administration revealed no major technological constraints to the construction of shallow draft ships. This report evaluated the possibility of utilizing such vessels on the lower Cape Fear River in North Carolina where several export coal terminals have been proposed. An existing 38-foot ship channel extending 30 miles upriver to the Port of Wilmington serves as a test site for the study.

SUMMARY AND CONCLUSIONS

Based on the study of potential coal export terminal sites conducted in Phase II of the Coastal Energy Transportation Study, a report on "alternative technologies" was prepared (CEIP Report No. 12, "Alternative Technologies for Transporting and Handling Export Coal", January 1982). The approach to this study was to briefly review the situation concerning coal export potential from the United States and North Carolina, then to look at existing and developing technologies for transporting and handling coal. Alternative technologies that were explored include:

Existing Technologies:

Conventional rail
Coal unit trains
Barges
Trucks
Pneumatic conveyor systems
Mechanical conveyor systems
Slurry pipelines
Coal handling facilities at ports

Developing and Proposed Technologies:

Mine-to-ship systems (combination of networks)
Midstream transfer ("lightering on" techniques)
Barge-carrying vessels
Shallow-draft vessels
Offshore deepwater concepts

The most promising of thses alternative technologies were then explored. The reader is referred to the January 1982 report for a description of the above-mentioned technologies.

Following this assessment of alternative technologies, three development scenarios for North Carolina's Coastal Study Area were proposed. Two specific areas for further study - a Landside Feasibility Study and an Offshore Terminal Feasibility Study - were recommended. The landside study was envisioned as an investigation of a rail-barge scenario for Morehead City and a wide beam, shallow draft vessel scenario for the Cape Fear region. Because coal transportation options for the Morehead City-New Bern corridor were already under investigation by the North Carolina Department of Transportation (see NCDOT Interim Report dated June 1982), only the Cape Fear wide beam, shallow draft vessel scenario is addressed in this report.

A summary of the methodology used in the shallow draft ship study, a list of specific findings, and an enumeration of three general conclusions are contained in the following paragraphs.

Methodology

Following a determination of future trends in dry bulk carrying ship sizes and regional demands for bulk commodities, the potential role of WBSD vessels for coal export from terminals along the lower reaches of the river was examined. Existing WBSD ship technology, with particular emphasis on a recent Maritime Administration (MARAD) study of large shallow draft bulk carrier technology, was reviewed. Competing alternatives, including conventional bulk carrier systems, channel dredging, and offshore systems were also investigated. Finally, a 65,000 dwt. WBSD vessel was assumed to satisfy the unique limitations of the Cape Fear River, and the resulting ship parameters were utilized to conduct a ship systems analysis.

Findings

The following items represent specific findings of the WBSD ship study:

- Despite the fact that ship size limitations of the U.S. Atlantic coast are approximately 80,000 dwt. at Hampton Roads and 60,000 dwt. at shallower ports, about half the world's coal fleet is presently 60,000 dwt. or larger.
- The use of wide beam, shallow draft carriers for coal export presents an opportunity to lower ocean transportation costs and relieve port congestion without requiring channel dredging.
- By lengthening and widening a ship without increasing its draft, its relative proportions are altered so the carrying capacity can be increased from 40 to 60 percent.
- The large beam of WBSD designs can present operational difficulties if channels are not wide enough or if shoreside cargo handling equipment does not have sufficient reach.
- Previous studies indicated that construction cost of a WBSD vessel is approximately 4 to 11 percent higher than a conventionally designed vessel of the same deadweight but greater draft.
- At constant draft, the Required Freight Rate (RFR), or cost per ton of owning and operating a ship, of the WSBD vessel is lower than the conventional vessel.
- In a limited depth channel, such as the Cape Fear River, several alternatives to the use of WBSD ships for coal export - shallow draft ship systems, channel and port dredging, and offshore deep water terminals - can be identified.
- A 65,000 dwt. WBSD collier with a 35-foot draft could safely navigate the 38 x 400-foot channel of the Cape Fear River from its mouth northward to the U.S. 17 highway bridge in Wilmington, but could not maneuver in the restricted channels north of this location.
- To handle the maximum potential 1985 and 1990 export coal demand or similar tonnages of other dry bulk commodities, on the lower Cape Fear River, the following number of vessels would be required:

Year	Annual Throughput (MTA)	Conventional Ships Annual	Conventional Ships Daily	WBSD Ships Annual	WBSD Ships Daily
1985	25	625	1.7	384	1.1
1990	37	925	2.5	569	1.6

- Exclusive use of a fleet of WBSD vessels in the U.S. - Northern Europe coal trade would require 32 ships by 1985 and 47 ships by 1990 to handle potential coal exports from the Cape Fear River region. Without a massive shipbuilding effort accompanied by the use of WBSD ships at other U.S. ports, production of any significant number of new ships by 1985 would not be realistic.
- Channel dredging, the most realistic alternative to a WBSD vessel concept along the river, would require a 45-foot channel to handle conventional 65,000dwt. colliers.
- Cost estimates for deepening the Cape Fear River from 38 to 45 feet total approximately $163 million plus $3.2 million annually for maintenance dredging.
- A new discounted present value analysis indicated that by 1990 the additional cost of constructing the required WBSD vessels would be offset by the cost saved by not dredging the channel.

Conclusions

The foregoing list of findings led to the following general conclusions regarding the feasibility of using wide beam, shallow draft bulk carriers to export coal from the Cape Fear River region:

- While softness in the current world market for U.S. coal will probably lead to delays or cancellations in the construction of new export terminals, the long term outlook for export coal demand remains optimistic. Most forecasts still call for significant increases by 1990 and dramatic increases by the year 2000. It is anticipated that at worst none of the five companies planning new facilities along the river will build during the 1980's and at best several will build terminals with reduced throughputs or extended time frames for export projections.
- If new terminals are constructed, they will be at a competitive disadvantage with other Atlantic coast coal ports with deeper channels. This disadvantage could be offset by one of the following actions:
    1) Remove all coal ships from the Cape Fear River by constructing an offshore terminal near Pender County to handle deep-draft bulk carriers;
    2) Dredge the river to 45 feet; or
    3) Employ a fleet of WBSD vessels without deepening the channel.
- An offshore, deepwater terminal would require massive injections of private capital, long term coal contracts, new (but currently available) handling and loading technology, and extensive permitting procedures to ensure environmental safeguards. Similarly, dredging appears to be an unattractive option because of high costs, lack of disposal sites, long lead time for approvals, and virtually insurmountable environmental concerns. Subject to precise engineering and economic feasibility studies, the WBSD vessel concept would indeed offer a challenging option for the marine transport of any future coal exports from the lower Cape Fear. The technology is available, but only extremely careful planning and long term commitments of interested parties could make it a reality.

1.0 PROJECT OVERVIEW

Rapid growth in world demand for U.S. coal exports has stimulated proposals for new or expanded export terminals in most ports along the U.S. Atlantic seaboard. North Carolina's ports are playing a vital role in this expansion, and plans for new terminals have moved swiftly since late 1980. During 1981, at least eight companies publicly expressed plans to develop export facilities for steam coal in the state. Five terminals along the Cape Fear River, two in Morehead City, and one offshore Pender or Carteret County were announced. Before exploring the potential of using a new shipping concept to serve some of these terminals, a brief overview of the circumstances leading to the expanding demand for export terminals is in order.

1.1 Background

The sudden demand for export coal apparently began in 1979 when OPEC oil producers drastically increased prices and European electric utilities quickly decided to switch from oil to coal in their power plants. The resulting burgeoning of demand manifested itself in the form of long vessel queues at U.S. ports, particularly Hampton Roads and Baltimore. Coal companies immediately sought new terminal sites and, because of their existing rail and port infrastructure and their proximity to Appalachian coal fields, the North Carolina ports at Morehead City and Wilmington became prime candidates for new export facilities. One company, Alla-Ohio Valley Coals, began shipping coal from their facility at the State Ports Authority terminal at Morehead City in May, 1981. Despite some financial problems in late 1981, the company has resumed coal shipments and is capable of handling an annual throughput of approximately three million tons.

While the other companies that want to build terminals in North Carolina have pursued permits and initiated planning studies, the world coal market has softened in 1982. Due in part to an international oil glut, spot coal prices have tumbled in Europe and ocean freight rates have fluctuated widely. In spite of these problems, 1981 was a record year for U.S. coal exports as 110 million tons (compared to 90 million tons in 1980) left U.S. ports. This figure was achieved despite a three-month strike by the United Mine Workers of America. In 1982, it appears that exporters with long-term contracts will continue to ship coal while spot (steam) sales will be very slow. Some coal experts predict that steam exports could fall by about 5 million tons in 1982 (Journal of Commerce, 2/22/81:1C). Because of the unpredictability of the world market, many coal companies are reevaluating their terminal construction plans and there is considerable evidence that several of the companies with sites leased along the Lower Cape Fear River may delay or terminate their planned terminals unless the market improves.

1.2 Scope and Objectives

Much of the information compiled on the location and impacts of coal terminals in North Carolina is available in the following studies:

a. N.C. Department of Natural Resources and Community Development, "Coal Export in North Carolina - A Review of the Issues," October, 1981 (NCDNRCD, 1981).

b. UNC Institute for Transportation Research and Education, "Coastal Energy Transportation Study." Four reports, 1980-82.

   1. CEIP Report No. 1 - "An Analysis of Transportation Needs to Support Major Energy Projects in North Carolina's Coastal Zone," December, 1980.
   2. CEIP Report No. 2 - "A Study of OCS Onshore Support Bases and Coal Export Terminals," August, 1981.
   3. CEIP Report No. 3 - "An Assessment of Potential Impacts of Energy-Related Transportation Developments on North Carolina's Coastal Zone," June, 1981.
   4. CEIP Report No. 4 - "An Analysis of State and Federal Policies Affecting Major Energy Projects in North Carolina's Coastal Zone," August, 1981.
   5. CEIP Report No. 12 - "Alternative Technologies for Transporting and Handling Export Coal," January, 1982.

As a group, these reports provide decisionmakers with an overview of the coal export process and the potential and problems it poses for North

Carolina. In an effort to mitigate some of the environmental problems inherent in the movement of coal by unit train, the possibility of utilizing alternative technologies to transport and handle steam coal was assessed in CEIP Report No. 12. A variety of new systems--including mine to ship techniques, midstream transfer, barge-carrying vessels, shallow draft vessels, and offshore deepwater loading terminals--were investigated. Most promising among the proposals, at least in its potential for application to the Cape Fear River, was the concept of using wide beam, shallow draft (WBSD) vessels in the relatively limited 38-foot ship channel rather than require additional dredging to accommodate larger conventional ships.

The major objective of this study of wide beam, shallow draft bulk carriers is to examine, from a regional viewpoint, the potential role of such vessels in the export of steam coal from terminals along the lower Cape Fear River. The first part of the study will review existing WBSD ship technology and its feasibility as a cost-effective option. The second focus of the study will be a comparative analysis among the competing alternatives--conventional bulk carrier systems, offshore systems, and channel and harbor dredging. This study provides a more rigorous economic analysis of these alternatives than was included in CEIP Report No. 12.) Finally, parameters with which to conduct a site-specific ship system analysis will be selected and the possibility of WBSD ships using the lower Cape Fear River will be evaluated.

2.0 VESSEL AND COMMODITY REQUIREMENTS

Before undertaking any detailed analysis of specific vessel designs, it is necessary to determine trends in ship sizes and regional demands for bulk commodities. Subsequent sections will review (1) the projected growth in dry bulk carriers and the anticipated dominance of larger vessels in future coal trade, and (2) the near-term estimates for coal exports from planned terminals along the Cape Fear River.

2.1 Projections of Vessel Sizes[1]

Most international coal shipments are transported by bulk carriers and combination vessels. Oceangoing bulk carriers are vessels specially designed for shipping a variety of dry bulk commodities such as iron ore, coal, grain, bauxite, or phosphate in large quantities. Combination, or OBO (ore-bulk-oil) carriers, vessels carry crude oil or refined petroleum products in liquid form or dry bulk commodities. At one time conventional cargo ships carried a substantial portion of world coal trade, but since the 1960's they have lost out to the economy-of-scale advantages enjoyed by the larger OBO's and bulk carriers.

The growing importance of larger vessels in the coal trade is illustrated in Table 1. A useful approximation between a bulk carrier's deadweight (dwt) tonnage and its principal dimensions is provided in Figure 1. Since most major U.S. Atlantic coast harbors have channel depths in the 35- to 45-foot range, it is obvious that the drafts and resulting deadweight tonnages restrict the size of the vessels bound for the coal export terminals. Further comparisons of typical ship dimensions are provided in Table 2, where it can be seen that current shipments from U.S. coal terminals are limited to vessels less than 100,000 dwt.

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[1]Because of its relevance to WBSD ship requirements, Section 2.1 has been reprinted from CEIP Report No. 12.

TABLE 1

NORTH AMERICAN COAL EXPORTS BY VESSEL SIZE, 1979

Vessel Size (dwt.)	Percentage
40,000	19
40,000 - 59,999	16
60,000 - 79,999	27
80,000 - 99,999	6
100,000 and over	32
	100

Source: OSG Bulk Ships Inc.; New York, February 1981

TABLE 2

SELECTED DIMENSIONS OF DRY BULK CARRIERS

Capacity (dwt.)	Overall length (ft.)	Beam (ft.)	Draft (ft.)
40,000	630	105	35
60,000	760	105	40
100,000	910	116	48
150,000	980	133	56
200,000	1,020	150	62
Limiting dimensions of Panama Canal	900	107	35.5

Source: Office of Technology Assessment, "Coal Exports and Port Development" April 1981

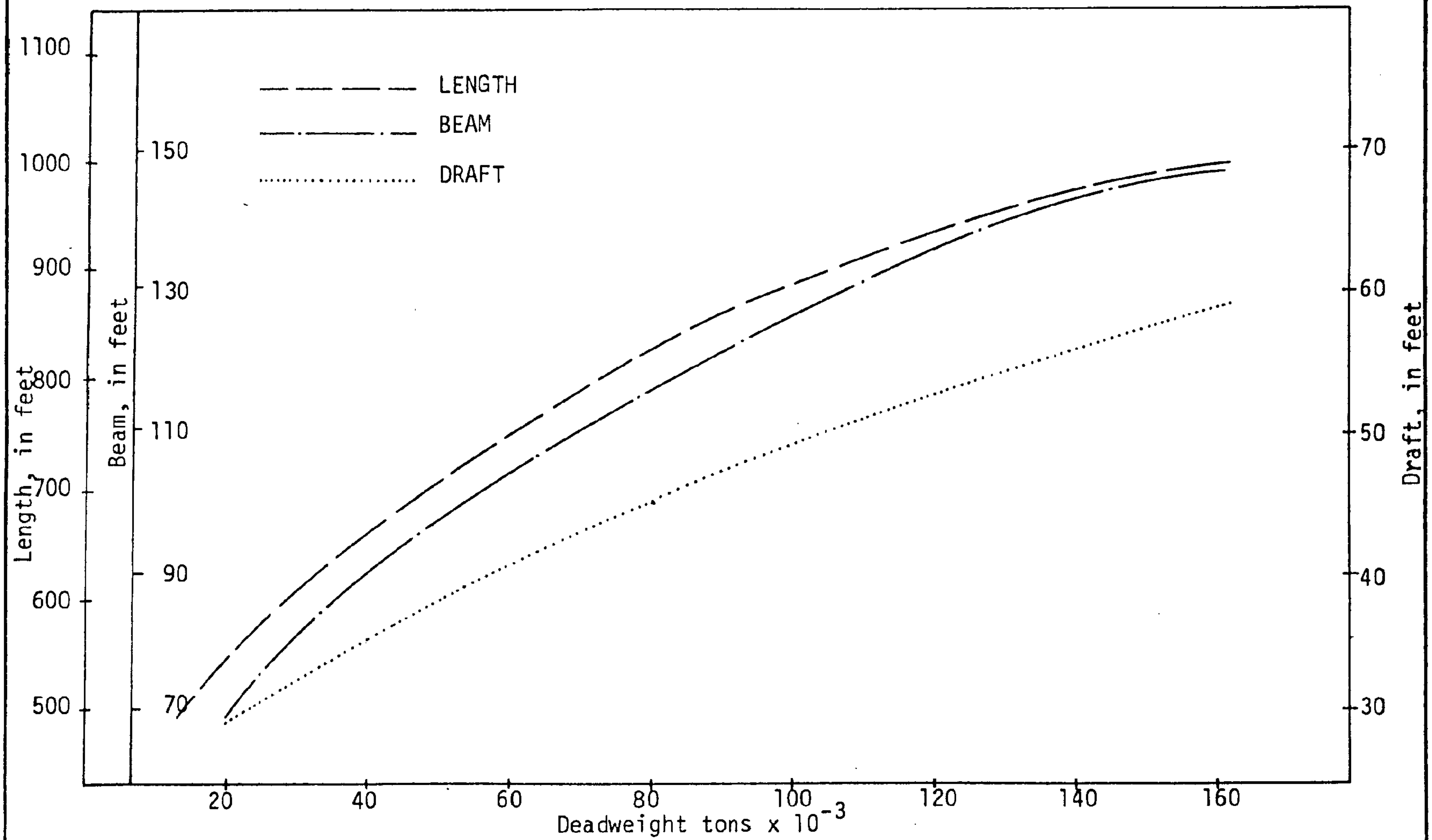


FIGURE 1

BULK AND ORE CARRIERS DIMENSIONS

Because unit costs of coal transportation increase with distance and decrease with ship size, the selection of ships tends to reflect a desire on the part of ship operators to use vessels as large as can be accommodated in the ports of concern. This has led to three general sizes of bulk carriers for coal: (1) 60,000 dwt. (Panamax size) which represents the median size for present coal shipments and is also the maximum size that can transit the Panama Canal; (2) 100,000 dwt., which is presently the average size of the largest long-haul colliers; and (3) 150,000 dwt., which is estimated to be a common size for future bulk carriers (ICE, 1980:III-10,11).

Future size distributions of coal ships are expected to reflect the importance of economies of scale in long-distance shipments. Despite the fact that ship size limitations on the U.S. Atlantic coast are approximately 80,000 dwt. at Hampton Roads and 60,000 dwt. at shallower ports, about half of the world's coal fleet is 60,000 dwt. or larger. So it appears that increasing ship sizes, while not being accompanied by commensurate increases in port depths in the United States, are being accommodated in other world ports. In fact, four export terminals and 14 receiving terminals are already in operation worldwide with facilities that can handle coal ships over 100,000 dwt. (Drewry, 1980). Deepwater export terminals at Richards Bay, South Africa; Roberts Bank, Canada; and Hays Point and Port Kembla, Australia are already providing strong competition for U.S. ports because of their ability to serve the larger carriers. Meanwhile, many receiving terminals in Western Europe and Japan have the capacity to handle coal carriers in the 120,000-160,000 dwt. range, and two ports in France are reported to be able to handle bulk carriers up to 650,000 dwt. (Lammert, 1981).

There is little reason to doubt that the anticipated growth in coal trade and potential economies of scale will make large bulk carriers more common. It has been estimated that within two decades, more than 50 percent of carriers capable of competing in the coal trades would exceed 100,000 dwt. and only 25 percent would be Panamax size and below (Lisnyk, 1981:52). Clearly, shipping capacity is not the critical factor in satisfying the anticipated growth in international coal trade. The critical question regarding American coal exports is whether or not U.S. ports can remain competitive with other world suppliers without deepening their channels, implementing offshore deepwater loading concepts, or developing new ship design concepts.

2.2 Commodity Future

Combined company estimates (NCDNRCD, 1981:Table A.2) of throughput for the five coal companies that have publicly announced plans for new terminals along the Cape Fear River are listed below:

Company	Location	Capacity
American Coal	West bank Northeast Cape Fear R.	3 - 7
Wilmington Coal Terminal	Downtown Wilmington	3
Williams Terminals	Lower Cape Fear R. near Southport	10 - 20
Utah International	Lower Cape Fear R. near Campbell Is.	5 - 7
Carolina Coal	SPA Terminal	unavailable

In view of the uncertainties of the world coal market in 1982, any attempt to convert these throughput capacities into annual export estimates is fraught with danger. Nevertheless, in order to select individual vessel designs, some projection of future tonnage is necessary. The following previously published estimates (NCDNRCD, 1981:Table A.4) will be used in this study:

	Export Coal Tonnage (MTA)
1985	25
1990	37

General location of the five proposed terminals along the Cape Fear River is depicted in Figure 2. A detailed description of the individual sites and the statue of their required permits is available in the 1981 DNRCD report. It should be noted that approximately 10 million tons of cargo passed through the Port of Wilmington in 1980. It is expected that this volume will continue to grow as the port expands its present facilities for containerized, break bulk, and liquid bulk cargoes. So the export coal tonnages that were previously cited must be added to other projected tonnages before evaluating the effects of increased rail and vessel traffic.

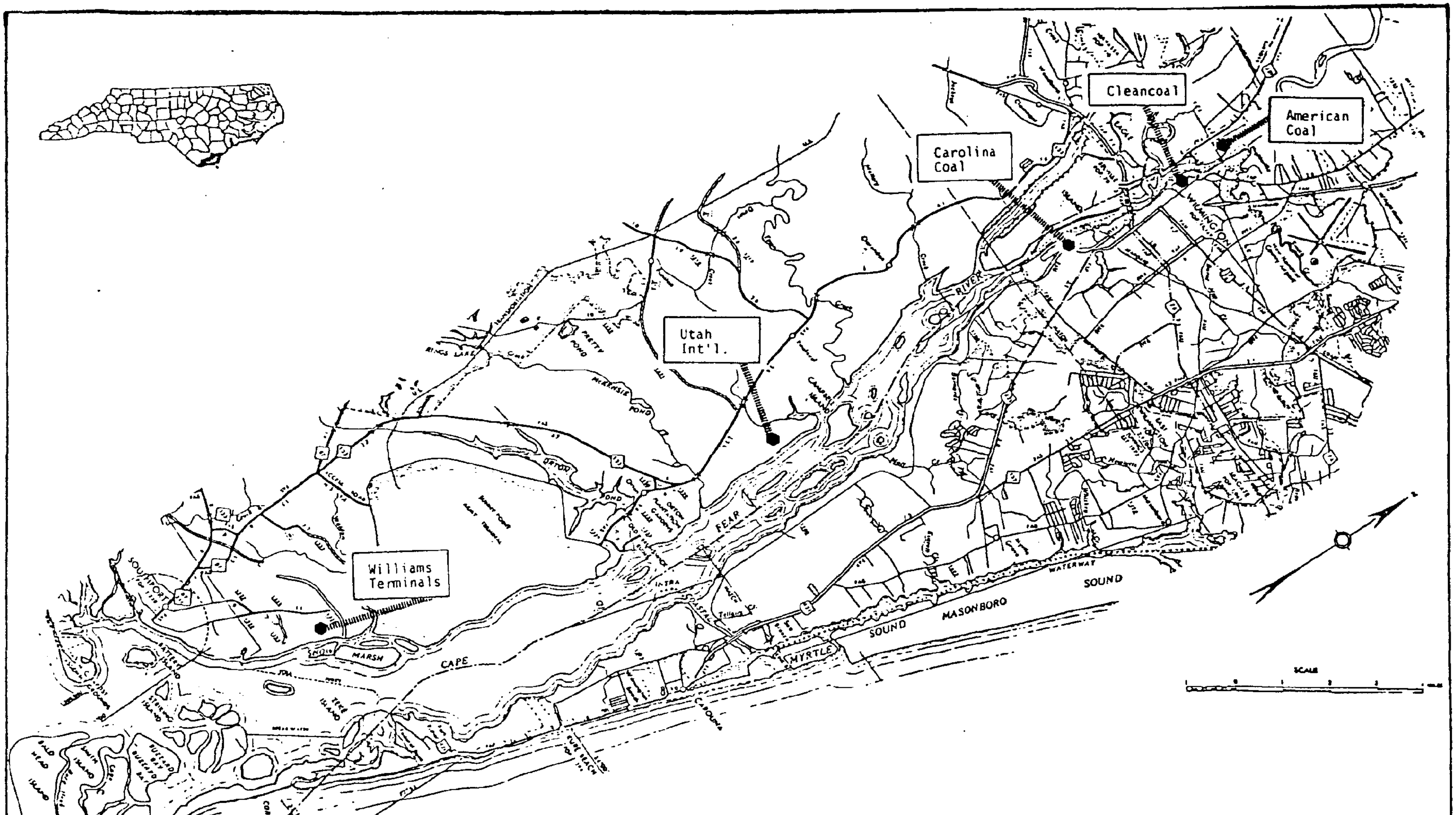


FIGURE 2
PROPOSED COAL EXPORT TERMINALS
CAPE FEAR RIVER

3.0 WIDE BEAM, SHALLOW DRAFT VESSEL TECHNOLOGY

An assessment of the future national/industrial requirements of large shallow draft bulk carrier technology was conducted for the U.S. Maritime Administration in 1975 as one element in the overall program of examining bulk shipping needs for the future and their impact on the economy and social well-being of the United States. Contained in three volumes, the study "Large Shallow Draft Bulk Carrier Technology Assessment" was prepared by M. Rosenblatt & Son, Inc., Naval Architects and Marine Engineers. In addition to providing both an engineering and economic analysis of WBSD ships and alternative technologies, the report also describes general approaches and specific analytical tools to carry out further studies. Background data from the Maritime Administration study, especially the findings related to WBSD ship technology, will be utilized extensively in this project.

3.1 State-of-the-Art

The use of WBSD bulk carriers for coal export presents an opportunity to lower ocean transportation costs while simultaneously relieving port congestion by using fewer ships. It also offers a unique opportunity to accomplish these two objectives without requiring channel dredging. For the typical 40- to 45-foot draft restriction encountered in most U.S. Atlantic coast ports, a substantial increase in deadweight tonnage can be obtained by accepting reasonable departures from "conventional" vessel proportions. If ships can be made larger by constructing them longer and wider, but not deeper, then a greater payload can be carried on a vessel operating in a restricted depth channel. The "conventional" design designation used herein refers to the proportional dimensions of ships which are currently in widespread use. Present dry bulk carriers are usually constructed to the following proportional dimensions (ICE Taskforce, 1980:V-25):

Length = 7 x beam

Beam = 1.8 x depth

Traditionally, naval architects have retained these basic length-to-beam and beam-to-depth ratios in the design of a wide range of ship sizes. As ship sizes increased, especially while tankers were evolving into supertankers, VLCC's and ULCC's, their length, beam and depth were increased in these conventional proportions.

3.1.1 Benefits and Limitations

Unfortunately, increases in vessel size have not been accompanied by commensurate increases in port channel depths in the United States. The development of shallow draft designs is an attempt to circumvent these channel limitations while taking advantage of the economies of scale available when using larger ships. By lengthening and widening a vessel without increasing its depth, the relative proportions are altered so the length is approximately 5.5 times the beam and the beam is 2.3 times the depth. For example, in a 38-foot deep channel such as is available on the Lower Cape Fear River, a conventional vessel with a 35-foot draft (distance from waterline to keel) could carry approximately 40,000 deadweight tons while a wide beam, shallow draft design could carry approximately 60,000 dwt. Further comparisons of the two designs are provided in Tables 3 and 4.

The concept of satisfying growth in demand by designing larger ships is well documented in maritime literature. The unique limitation of the WBSD approach is the imposition of a draft constraint on the vessel design procedure. As a result, the ship design that has been selected by naval architects is not the most economical vessel for its deadweight but is the one that will produce the lowest unit transportation cost for a water depth limitation that is less than the optimum draft (Lisnyk, 1981: 47).

Although the benefits of shallow draft vessels have been known for many years, construction of these vessels has not been warranted for the following reasons:

(1) Amounts of commodities and trade route patterns have not placed sufficient demand on the industry.

(2) The presence of a 106-foot beam constraint imposed by the lock dimensions of the Panama Canal has eliminated some of the flexibility of wide body ships.

Table 3
Conventional vs. WBSD Vessels

Maximum Deadweight

Draft, feet	Conventional Design	Shallow-Draft Design
35	40,000	60,000
40	60,000	90,000
45	85,000	125,000
50	110,000	170,000
55	150,000	225,000

Table 4
Conventional vs. WBSD Vessels

Draft, Feet

Deadweight Tons	Normal for Conventional Design	Shallow-Draft Design
60,000	40	35
90,000	46	40
125,000	53	45
170,000	59	50
225,000	56	55

Source: Lisnyk, J. A., "Ocean Shipping Component," Proceedings of AAPA Coal & Ports Seminar, Mobile, Ala., 1981, p. 47.

With the recent changes in demand for export coal, both of these limitations are becoming less important. Steam coal movements have become significant and in many cases, e.g., eastern U.S. to northern Europe or western Canada to Japan, the trade routes are relatively fixed. Furthermore, the width constraint of the Panama Canal is related more to metallurgical than to steam coal. Shipments of metallurgical coal typically originate at U.S. Atlantic or Gulf ports, transit the Canal, and are bound for Japanese steel mills. Steam coal shipments from the same U.S. ports would more likely be destined for steam generating plants in northern Europe.

3.1.2 Economic Consequences

The possibility of increasing vessel capacity without a corresponding increase in draft implies certain economic consequences for both shippers and operators. In the case of the operator, the use of WBSD vessels, which can provide a 40 to 60 percent increase in cargo capacity at a given draft (ICE taskforce, 1980:V-28), promises that any growth in coal demand can be satisfied with fewer ships. As indicated in Figure 3, economies of scale created by these payload increases can produce net savings of about 20 percent in coal transported from the U.S. East Coast to Europe.

Because all existing and prospective coal exporting ports on the U.S. and Gulf coasts have depth limitations for the larger bulk carriers (see Tables 1 and 2), WBSD vessels for transporting slurried or dry steam coal appear to have potential both for lowering transportation cost and for decreasing port congestion. Presently, most oceangoing colliers are foreign owned and thus the foreign shipper would be required to finance and develop the shallow draft vessel. Because these vessels are more expensive to build than an equivalent capacity conventional ship, it is easy to understand why foreign vessel owners are urging the U.S. government to dredge deeper harbors rather than investing their own funds in more expensive vessels.

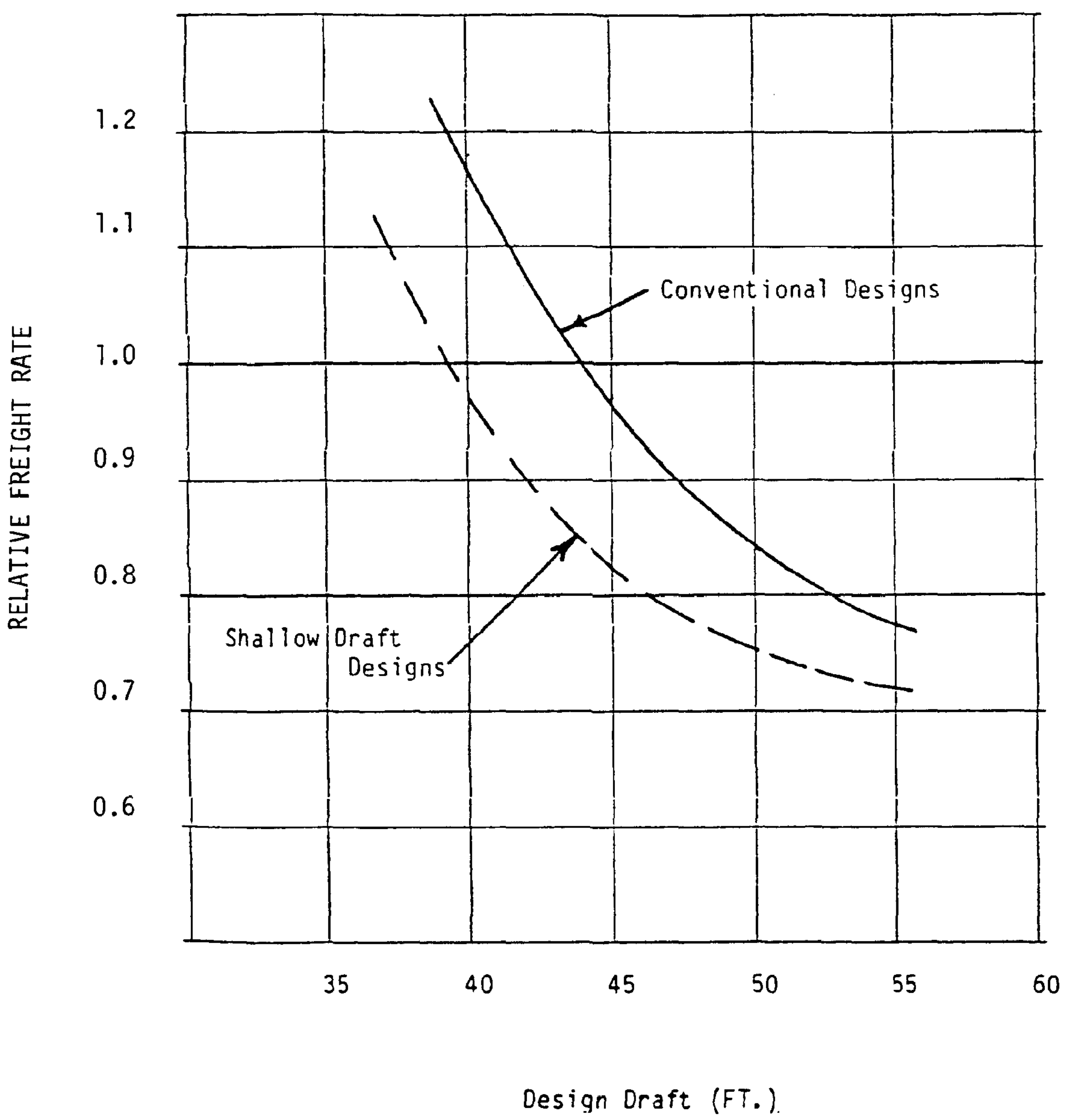
3.2 Shallow Draft Ship System

An extensive search of the published literature on ship resistance, maneuverability, and control requirements for large shallow draft ships was conducted in the Maritime Administration (MARAD) study. Results of this

FIGURE 3

TYPICAL OCEAN FREIGHT RATES

FOR COAL CARRIERS



Source: Interagency Coal Task Force, "Report on Ports and Ocean Transportation", 1980, p. V-29.

search led to the development of a methodology for establishing the optimum characteristics of a WBSD bulk carrier. Section 3.2.1 summarizes the methodology used in the MARAD study.

3.2.1 MARAD Model

An analytical model incorporating the essential design and cost relationships for the ships under consideration was devised. The computer model used in the study develops a ship design from a small set of initial variables. It is similar to previous models developed under MARAD contracts MA-4535 "Optimization Studies for a Standardized Dry Bulk Carrier" and 2-36252 "Bulk Commodities Form Changes and Alternative Transportation Modes." The data, which define the problem to be solved, include three major categories:

Ship's Design Data. This category enables the user to select ship type, ship size, fuel, stowage factor and required endurance.

Ship's Operating Data. Under this category, the user selects trade characteristics such as voyage length, cargo handling rates, number of ports, crew size, etc.

Constraints. Specific values imposed on the design such as draft, beam, length, depth and speed are included in this category.

Next, a small set of independent variables that defines one possible design is used to calculate all other ship characteristics. The following set of variables was utilized:

$$
\begin{aligned}
Cb &= \text{block coefficient} = CB \\
V/\sqrt{L} &= \text{speed-length ratio} = VL \\
B/H &= \text{beam-draft ratio} = BH \\
L/B &= \text{length-beam ratio} = BL \\
L/D &= \text{length-depth ratio} = FLOD
\end{aligned}
$$

For a given displacement (Δ) this set of values can generate one unique ship configuration.

The design process then begins with the convergence of the independent variables into basic ship dimensions. Several relationships are used to determine the initial dimensions:

a) Length = L = $\sqrt[3]{\frac{\Delta \times 35 \times BH \times (BL)^2}{CB}}$

b) Beam = B = L/(BL)

c) Draft = H = B/(BH)

d) Depth = D = L/(FLOD)

e) Speed = V = $L^{\frac{1}{2}} \times (VL)$

Following the selection of ship dimensions, propulsion characteristics and candidate ship acquisition and operation costs are calculated so designs can be compared. Once the design procedures are established, a measure of cost effectiveness is needed to find the best possible design for a given route. The criterion known as the required freight rate (RFR), or average annual cost divided by amount of cargo carried annually, was selected as the most appropriate measure of cost effectiveness for this study.

The most likely candidate for demonstration of WBSD ship economies is one in which draft is fixed, while length, beam, depth and block coefficient are allowed to vary. When the additional constraint of draft (H) is kept constant, either L/B or B/H can be eliminated. The MARAD model dropped B/H from the set of variables and H from the previous equations.

The parameters chosen for the evaluation of the WBSD vessel hull characteristics were varied systematically within a constrained region to yield the optimum ship's hull characteristics. The following variables and accompanying ranges were selected for investigation by the ship's selection parametric model:

$4.5 \leq L/B \leq$ Chart Limit of L/H = 22

$0.75 \leq Cb \leq 0.875$

$10.0 \leq L/D \leq 15.0$

$0.40 \leq V/\sqrt{L} \leq 0.65$

Six deadweights were investigated for each draft constraint (a range of 35 to 55 feet was selected to reflect U.S. port limitations), each of which had a lengthy series of characteristics (labor, operating and fuel costs, voyage length, etc.) held constant. Utilizing average loading rates, complete runs over the whole range of draft and deadweight were made for tankers and OBO's while dry bulk carriers were investigated only at discrete points corresponding to a trade analysis. Typical results for an OBO (Figure 4) are shown in the form of a series of curves where the maximum ship size corresponding to the minimum Required Freight Rate (RFR) for each draft constraint can be easily determined.

Finally, the remaining five equations were used in the design optimization procedure and the cost measure, RFR, was compared with payload to find the minimum cost design. Following an analysis of several bulk commodities, the six preliminary ship designs listed in Table 5 were selected for further examination. Table 6 provides the general characteristics of the minimum RFR for OBO's and for a 90,000 dwt., 40-foot draft dry bulk carrier. As a result of multiple design evaluations conducted for tankers and OBO's, both the maximum dwt. and optimum dwt. are projected in Figure 5. It is obvious that a virtually unlimited number of design possibilities could exist between the conventional and maximum deadweight designs. The optimum deadweight curve is a function of voyage constraints and cost parameters used in the evaluations. Optimum dwt. designs of WBSD vessels are approximately 40 to 60 percent larger than conventional designs.

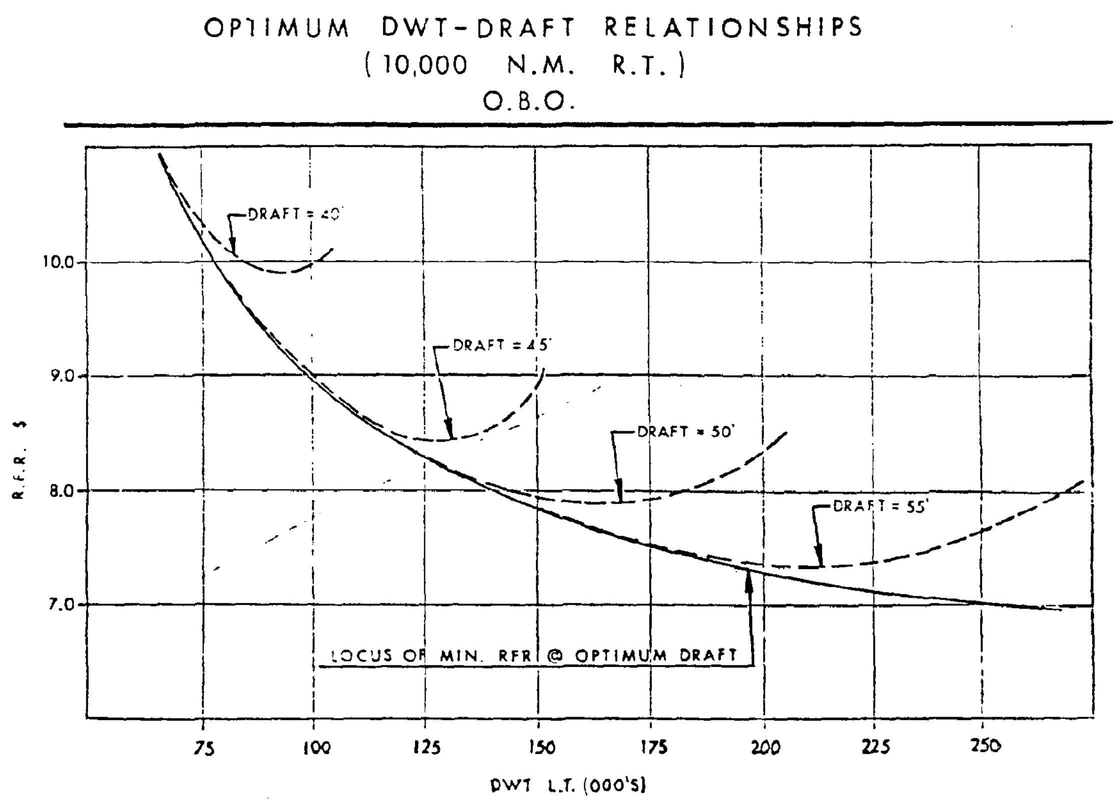
3.2.2 Vessel Selection

Based on shipping trends and projected bulk commodity flows for the years 1985-2000, the following vessel designs were selected in the MARAD study for shipping system analysis:

1. 90,000 dwt., 40-foot draft, WBSD bulk carrier, strengthened for carriage of ore
2. 95,000 dwt., 40-foot draft, WBSD tanker
3. 165,000 dwt., 40-foot draft, WBSD tanker
4. 125,000 dwt., 45-foot draft, WBSD OBO
5. 160,000 dwt., 50-foot draft, WBSD OBO

The ship system analysis was performed to determine how penalties associated with increasing ship size at constant draft compare with the benefits derived from ship capacity growth.

FIGURE 4



Source: M. Rosenblatt & Son, Inc., "Large Shallow Draft Bulk Carrier Technology Assessment," prepared for Maritime Administration, 1975: Figure 2.2 - 10

TABLE 5

PRELIMINARY SHIP CHARACTERISTICS

Item		Dry Bulk	O.B.O.	O.B.O.	O.B.O.	Tanker	Ore/Oil
Draft, Mld.	Ft.	40.	40.	45.	50.	55.	55.
Length, B.P.	Ft.	805	805.	860.5	950.	981.6	998.7
Beam, Mld.	Ft.	140.	140	157.5	175.	192.5	192.5
Depth, Mld.	Ft.	62.5	67.5	73.	80.	82.	81.5
Displacement, Mld.	Ft.	107.162	107.162	144.630	197.125	244.970	251.654
Deadweight, design	K.L.T.	90.	90.	125.	170.	215.	215.
CB	K.L.T.	.832	.832	.83	.83	.825	.833
L/B		5.75	5.75	5.46	5.43	5.1	5.19
L/H		20.12	20.12	19.11	19.	17.85	18.16
L/D		12.88	11.93	11.79	11.88	11.98	12.26
B/H		3.5	3.5	3.5	3.5	3.5	3.5
B/D		2.24	2.07	2.16	2.19	2.35	2.36
H/D		.64	.593	.617	.625	.671	.675
Cargo Volume	Vol.Ft.^{3}(MM)	4.441	4.088	5.308	7.129	9.165	9.369
Clean Ballast	Vol.Ft.^{3}(MM)	N/A	1.919	1.958	2.629	2.976	2.942

Source: M. Rosenblatt & Son, Inc., "Large Shallow Draft Bulk Carrier Technology Assessment," prepared for Maritime Administration, 1975: Table 2.2-1.

TABLE 6

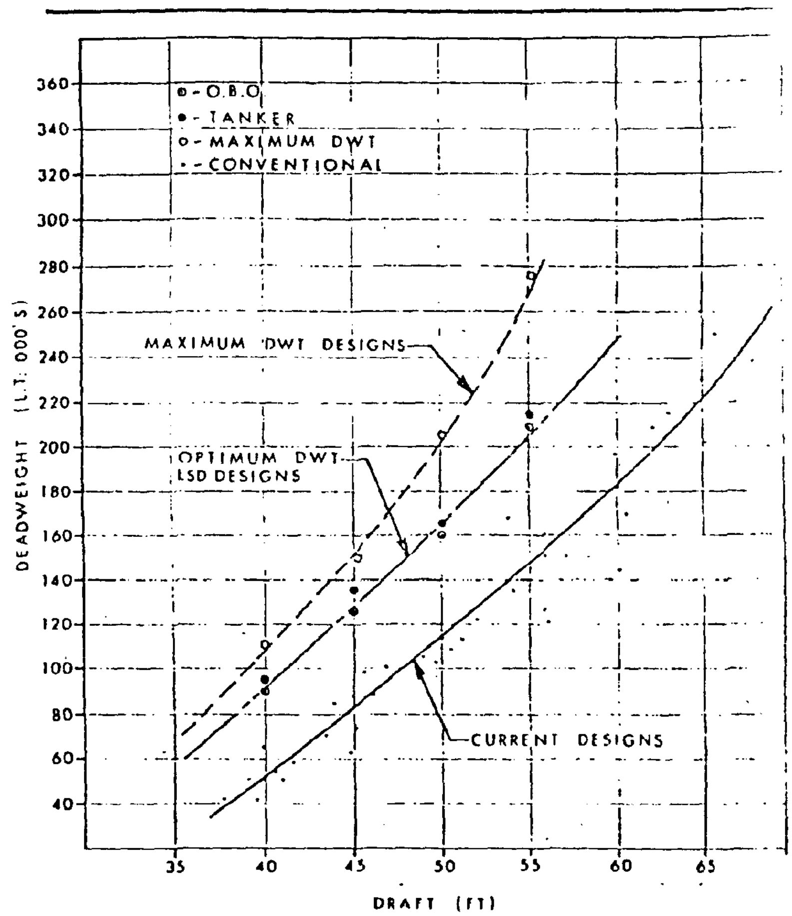
OPTIMUM BULK & O.B.O. CHARACTERISTICS

Item		Bulk	O.B.O.	O.B.O.	O.B.O.	O.B.O.
Length, B.P.	Ft.	843.1	840.5	933.5	970.5	1050.5
Beam, Mld.	Ft.	144.1	147.5	161.1	192.8	212.1
Depth, Mld.	Ft.	58.8	58	65.4	70.9	76.9
Displacement, Mld.	K.L.T.	111.697	115.701	158.810	201.337	266.868
Deadweight, design	K.L.T.	90	90	125	160	210
Cargo Volume	$Ft.^3$(MM)	4.413	3.963	5.528	7.079	9.305
Clean Ballast Vol.	$Ft.^3$(MM)	.927	1.409	1.845	1.904	2.331
Speed, Full Load	Knots	13.3	14	13.43	13.45	13.67
SHP, Installed	H.P.	16,700	19,690	21,653	27,556	24,441
CB		.822	.816	.821	.78	.77
L/B		5.72	5.7	5.8	4.93	4.95
L/D		14.02	14.5	14.27	13.39	13.67
L/H		21.08	21.01	20.74	19.41	19.10
B/H		3.60	3.69	3.58	3.86	3.86
B/D		2.45	2.54	2.46	2.72	2.76
H/D		.68	.69	.69	.71	.72
Cost (each of 3 $1974)	$MM	35.3	41.3	49.3	56.8	71.3
R.F.R. (10000 H.M.R.T.)	$/L.T.	9.68	9.8	8.26	7.74	7.27

Source: M. Rosenblatt & Son, Inc., "Large Shallow Draft Bulk Carrier Technology Assessment," prepared for Maritime Administration, 1975: Table 2.2-4.

FIGURE 5

COMPOSITE VESSELS
DRAFT vs DEADWEIGHT



Source: M. Rosenblatt & Son, Inc., "Large Shallow Draft Bulk Carrier Technology Assessment," prepared for Maritime Administration, 1975: Figure 2.2 -14.

All the vessels exhibited a wider than usual beam and shallower than usual draft for their respective deadweights. The hull form used in the analysis was designed for single screw propulsion and will require an unusually large rudder for maneuvering. However, these vessels can achieve hydrodynamic properties very close to those of conventional designs. Thus, at or near economical speed, they will not be severely penalized for hull resistance.

In the case of dry bulk and combination carriers, the large beam of the WBSD designs can present operational difficulties where channels are not wide enough or cargo handling equipment does not have sufficient reach. This aspect of the ship design will require careful consideration.

Construction cost of a WBSD vessel was found to be approximately 4 to 11 percent higher than a conventionally designed vessel of the same deadweight but greater draft. At constant draft, the RFR for the WBSD ship is lower than the conventional ship. Thus, the 40 to 60 percent greater carrying capacity yields an advantage between 6 and 16 percent for OBO's and between 4 and 19 percent for tankers, both drawing 40- to 55-foot draft.

The results show clearly that with no draft restrictions, the conventional vessel is more efficient (lower RFR) than the WBSD design. However, at constant draft, the WBSD vessel is preferable if an increase in lot size is warranted.

4.0 ALTERNATIVE SHIPPING SYSTEMS

Over the next decade, the expansion of world demand for steam coal may force the introduction of new technologies to transport and handle coal for export. In many U.S. ports, expansion of existing transfer facilities and transportation networks may not always be the most effective approach. Especially in areas where new mines are being developed, it may be more reasonable to develop mine-to-ship systems that could bypass existing port congestion.

In a limited depth channel, such as the Cape Fear River, several alternatives to the use of wide beam, shallow draft ships for coal export can be identified:

- Do nothing - continue to use a shallow draft ship system
- Channel and port dredging
- Offshore deepwater terminals

Brief descriptions of each of these alternatives are presented in the following sections.

4.1 Conventional Bulk Carrier Systems

Three basic types of bulk carriers - tankers, dry bulk carriers, and combination carriers - are in general use in the maritime field today. Since tankers are used to transport only liquid bulk commodities, they will not be discussed in this report. Dry bulk carriers, as their name implies, transport unpackaged dry commodities such as ores, grains, and coal.

Because the growth in dry bulk commodities has been less rapid than the growth of crude oil shipments, increases in carrier sizes have been much less spectacular. Although the largest supertankers now exceed 500,000 dwt., relatively few dry bulk carriers exceed 150,000 dwt. To facilitate the handling of a variety of commodities, dry bulk carriers have recently been modified into two types of combination carriers -

bulk/oil (OBO) and ore/oil carriers. Three general sizes of dry bulk carriers for coal (colliers) have evolved in recent years. As discussed in Chapter 2, the 60,000 dwt. collier reflects the limiting dimensions of the Panama Canal, the 100,000 dwt. collier represents the average size of long-haul carriers, and the 150,000 dwt. collier will probably be the common size for future vessels. Unfortunately, channel depth restrictions (40 feet or less) at most U.S. Atlantic ports limit collier size to 60,000 dwt. except at Hampton Roads and Baltimore where a 45-foot channel can accomodate 80,000 dwt. vessels.

Continuation of the do-nothing option may not cause noticeable problems in ports with low volumes of ships. However, as port congestion increases, increased transport costs would effect the U.S. export position and have a negative effect on our balance of payments. It is also reasonable to expect that foreign coal buyers will avoid shallow draft ports that prevent them from realizing economy of scale advantages of the larger bulk carriers.

4.2 Channel and Port Dredging

Many members of the maritime community are strongly persuaded that the United States must deepen several of its harbors to accomodate supertankers and large dry bulk carriers. Dredging advocates include numerous foreign shippers who operate these vessels and have access to deepwater ports in many locations outside the U.S.

As discussed in CEIP Report No. 12, the U.S. Army Corps of Engineers has undertaken harbor and channel deepening studies at Hampton Roads, Mobile, and New Orleans. In each case, the proposed depth is 55 feet. Deepening the 42-foot channel to Baltimore to 50 feet has been authorized since 1970 but has been delayed because of a lack of disposal sites for dredged material.

The dredging option offers the obvious advantage of improving the U.S. position in world bulk trade by accomodating the growing fleet of large bulk carriers. However, it also has a number of potentially serious drawbacks:

- Initial costs and annual maintenance costs may be extremely high.
- Environmental disruptions are of increasing concern.
- Locating suitable disposal sites is becoming very difficult, especially where the channel is lengthy.
- Allocating the cost responsibility between federal and local governments has not been resolved.
- Dependence on foreign flag vessels may increase.

4.3 Offshore Systems

In 1980, the Interagency Coal Export Task Force predicted that within 20 years a common collier size will be about 150,000 dwt. and for such vessels a channel depth of at least 58 feet will be required. Under these conditions the 55-foot channels and harbors discussed under the dredging option would be inadequate for ships larger than about 130,000 dwt. As a growing portion of the dry bulk fleet is accounted for by larger vessels, the need for even deeper channels would once again have to be addressed.

An alternative to channel dredging, the construction of offshore deepwater loading facilities, appears to hold considerable promise for future coal exports. Design alternatives for offshore concepts include either an industrial island complex or a single point mooring connected to shoreside storage by means of a submarine pipeline. High cost and lengthy permitting and construction time requirements probably rule out the industrial island concept as a viable option for North Carolina in the near future. A single point mooring system off the Pender County coast has been explored by at least two companies, and a similar system off the Carteret County coast has been suggested.

Proposals for transferring coal from onshore storage sites to offshore loading sites have been detailed in two recent studies:

- "Pacific Bulk Commodity Transportation System - Phase II," Boeing Engineering and Construction, 1979.
- "Cosmos: Innovation in the Export of U.S. Steam Coal," Wheelabrator-Frye Inc., Hampton, New Hampshire, 1981.

These studies indicate that the technology is available to develop offshore terminals capable of handling 10-16 million tons of coal annually.

Both the Boeing and Wheelabrator - Frye concepts are designed to bypass existing ports. In spite of their initial high cost and potential for negative regional and environmental impacts, offshore systems offer several major advantages:

- ° Avoidance of rail congestion and grade crossing problems in urban areas.
- ° Reduction of terminal and harbor congestion.
- ° Elimination of the need for channel dredging.
- ° Use of private rather than public funds.

As foreign coal demand and average ship size increase in the future, it appears that offshore loading facilities for slurried coal could serve as a very attractive alternative to conventional terminal facilities.

5.0 WBSD SHIP SELECTION FOR LOWER CAPE FEAR RIVER

In order to accomodate maximum potential coal export tonnages of 25 and 37 million tons annually for 1985 and 1990, respectively, from terminals along the Cape Fear River (See Section 2.2), a substantial fleet of dry bulk carriers would be needed. The present 38-foot channel depth effectively limits conventional vessel size to approximately 40,000 dwt. Thus, about 625 shiploads of coal annually could be added to existing vessel traffic in the river by 1985, with increases to about 925 shiploads by 1990. These throughputs would add an average of 1.7 to 2.5 conventional ships per day to existing vessel traffic.

5.1 Vessel Dimensions

If a wide beam, shallow draft ship system could be implemented along the Cape Fear River, the new vessels would have to be capable of being safely maneuvered in the existing ship channel and turning basin. Detailed design characteristics for such a vessel are listed in Table 7. Variables were selected to satisfy the limits prescribed in the MARAD model and discussed in Section 3.2 of this report. The resulting 65,000 dwt. collier would be a vessel specifically designed to meet the requirements of the Cape Fear River while maximizing the ship's deadweight capacity.

Specifically, the Cape Fear WBSD vessel would be limited to a 35-foot draft and have length and beam dimensions that would permit safe navigation in the 38- by 400-foot channel. By slightly altering conventional ship design ratios, the recommended WBSD vessel would offer a capacity increase of approximately 60 percent over the conventional 40,000 dwt. vessel. In addition to economies of scale created by this payload increase, the daily number of colliers in the river could be reduced to 1.1 in 1985 and 1.6 in 1990.

TABLE 7

Recommended Design Characteristics of
WBSD Vessel for Cape Fear River

Item	
Draft (H)	35 ft.
Length (L)	653 ft.
Beam (B)	124 ft.
Depth (D)	54 ft.
Deadweight, design (DWT)	65,000 long tons
Block coefficient (C_B)	0.8
Length-beam ratio (L/B)	5.25
Length-draft ratio (L/H)	21
Length-depth ratio (L/D)	12
Beam-draft ratio (B/H)	3.5
Beam-depth ratio (B/D)	2.3
Draft-depth ratio (H/D)	.65
Speed, full load (V)	12.8 knots
Cost	$857/dwt.*
Required freight rate	$19/long ton*

* See Section 6.1 for cost and rate calculations

5.2 Channel Conditions

Geometrics and dimensions of the existing Cape Fear River channel are depicted in Figures 6 and 7. These maps, which were revised in 1980, and the following detailed description[1] of the channel were provided by the Wilmington office of the Corps of Engineers:

> PROJECT: A channel, 40 feet deep, 500 feet wide, through the ocean bar, thence 38 feet deep, 400 feet wide, with increased width at bends, to the upper end of the anchorage basin (foot of Castle Street) at Wilmington; thence 32 feet deep, 400 feet wide, to Hilton Bridge over Northeast Cape Fear River, with increased widths at bends; an anchorage basin at Wilmington, 38 feet deep, 2,000 feet line, 900 feet wide at the upper end, 1,100 feet wide at the lower end, with approaches, 1,500 feet long at the upper end and 4,500 feet long at the lower end, with some widening of the transition channel at the downstream end; a turning basin opposite the principal terminals at Wilmington, 32 feet deep, 1,000 feet long, 800 feet wide, with suitable approaches at each end; a channel, 12 feet deep, 100 feet wide, northwestward from the Intracoastal Waterway at Snows Cut to the main river channel; and a channel, 25 feet deep, 200 feet wide, from Hilton Bridge to a point 1-2/3 miles above, including a turning basin, 25 feet deep, 700 feet wide, and 500 feet long, at a point 1.25 miles above the bridge.

It should be noted that a fully loaded WBSD vessel of the type described in the previous section could utilize the entire length of the Cape Fear River from the ocean bar to the U.S. 17 highway bridge in Wilmington. Because of its 35-foot draft, it would not be able to maneuver in the 32-foot channel from the U.S. 17 bridge to the Hilton railroad bridge, at least not in a fully loaded condition; nor would it be usable in the present 25-foot channel north of the Hilton bridge. A review of the channel and anchorage basin dimensions does not reveal any restrictions for WBSD vessel navigation. In fact, vessels larger than the WBSD design have previously been handled in the Wilmington harbor without difficulty. It is entirely feasible, therefore, that WBSD ships could use the Lower Cape Fear as far upriver as the Highway 17 bridge.

[1] U.S. Army Corps of Engineers, "Wilmington Harbor, N.C. -Condition of Improvement", September 30, 1979.

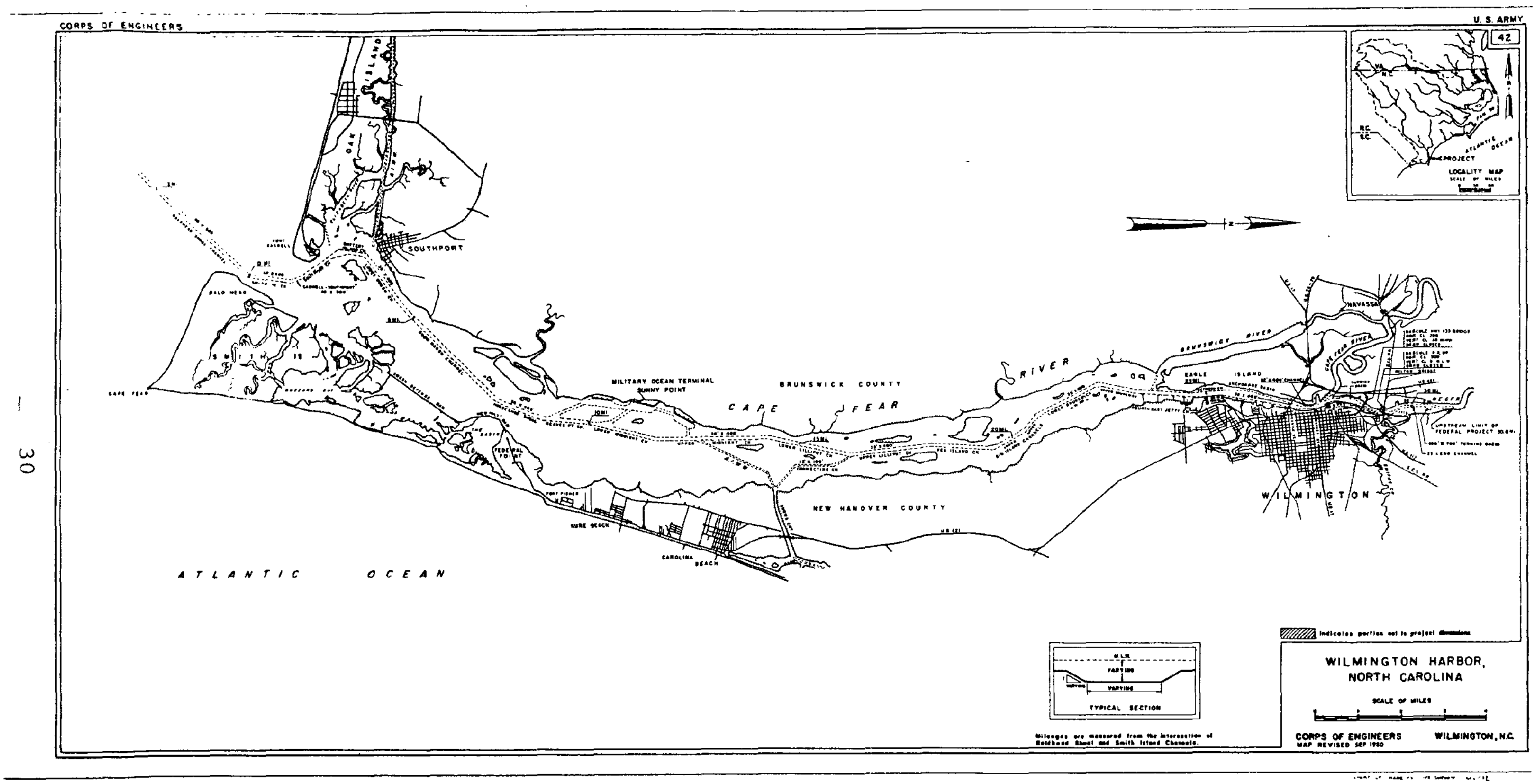


FIGURE 6

Cape Fear River Channel

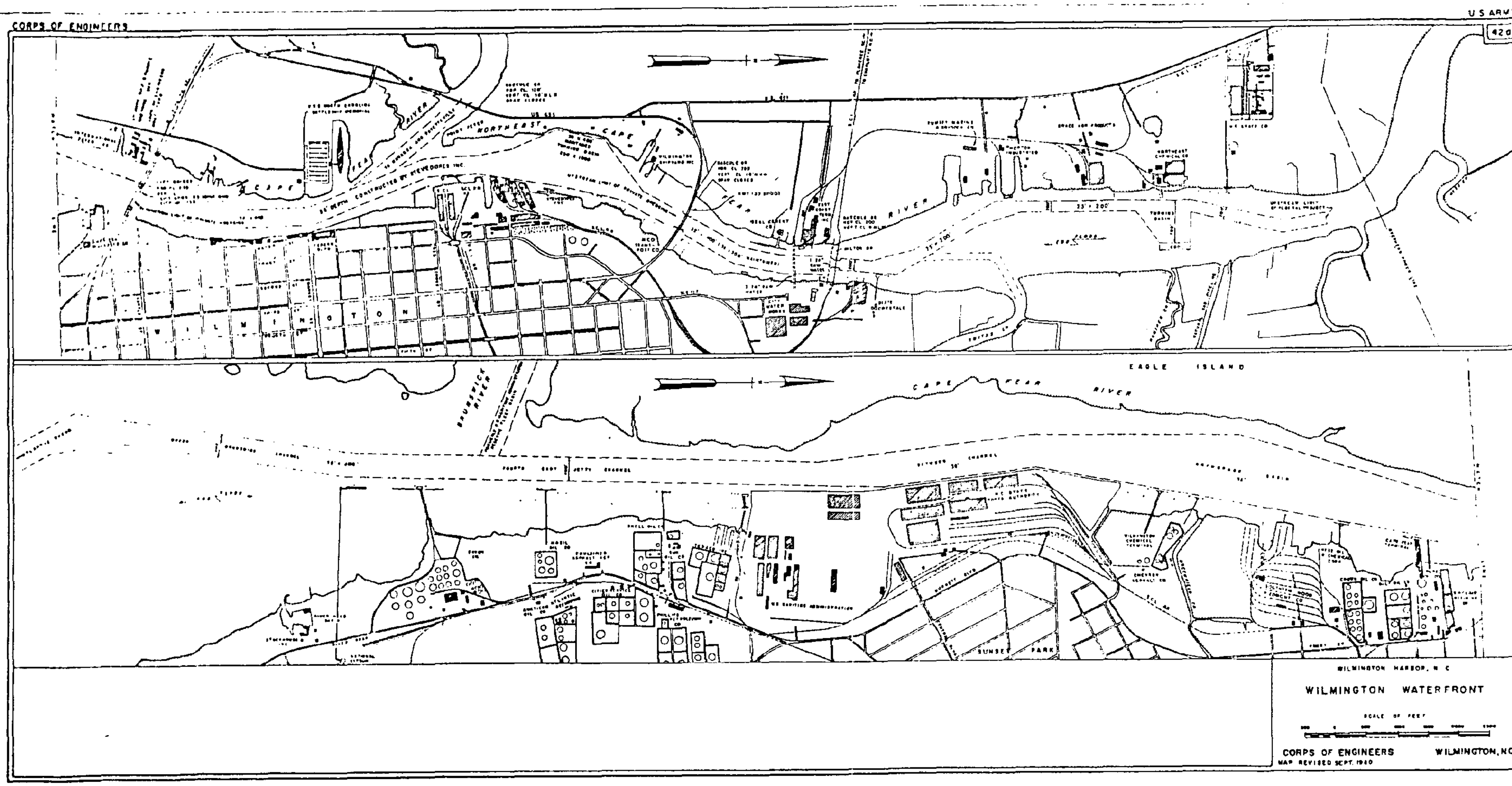


FIGURE 7
Channels in Wilmington Harbor

6.0 Ship Systems Analysis

Time and budget limitations prohibited a more exhaustive analysis of a spectrum of alternative ship designs. No attempt was made to select "the optimum" WBSD ship for conditions of the Cape Fear River. Rather, characteristics of a single vessel that would produce lower unit transportation costs for the available channel limitations were specified.

6.1 Cost Considerations

The MARAD study indicated that construction cost of a WBSD vessel was approximately 4 to 11 percent higher than a conventionally designed vessel of the same deadweight but deeper draft. However, cost/dwt. is estimated to be 3 to 17 percent lower than conventionally designed ships of equal draft. For the Cape Fear WBSD vessel an average cost/dwt. of $857 was obtained by inflating 1974 costs at 5% annually. The resulting WBSD vessel cost is estimated to be $56 million.

One of the most acceptable merit measures for comparison of alternative ship designs, as discussed in Section 3.2.1, is the Required Freight Rate (RFR), which is simply the cost per ton that results when the average annual cost of owning and operating the vessel is divided by the number of tons transported each year. Required Freight Rate can be expressed as follows:

$$\text{RFR} = \frac{\text{Ship acquistion cost x A/P factor + Annual Operating Cost}}{\text{Payload x Number of trips/year}}$$

Again, average industry values were inflated to 1982 dollars for the proposed WBSD vessel to produce a RFR = $19 per long ton. If it is assumed that the ship is engaged in the U.S. - Northern Europe coal trade and can make a round trip every 30 days, a fleet of at least 32 vessels would be required in 1985 and an additional 15 by 1990 to handle Cape Fear region exports exclusively.

6.2 Investment Appraisal

Rather than attempt to quantify the benefits of the WBSD concept vis a vis channel dredging, rough estimates of the capital and maintenance costs of dredging the Cape Fear River and the differential costs of constructing a fleet of new ships were prepared. Cost tradeoffs then take the form of a comparison between the existing 38-foot channel with a fleet of 65,000 dwt. WBSD vessels versus a deeper 45-foot channel that would require dredging but could accomodate conventional bulk carriers up to 65,000 dwt.

As previously indicated, there is relatively little difference in the construction costs of WBSD vessels and conventional vessels of the same deadwieght but deeper draft. The 10 percent higher cost for the WBSD ship that was assumed in this study could be substantially greater during periods of excess bulk shipping capacity when conventional ships could be purchased at significant discounts. But, in order to evaluate these savings, some estimate of dredging costs must be considered.

The usual procedure for estimating the cost of dredging is to compute the volume of dredged material, in this case the difference in volume required for a new 45-foot channel and the volume of the existing 38-foot channel. This can be accomplished by multiplying the length of the channel by the area of its cross section. Average end areas over convenient distances are often used in the following relationship:

$$\text{Volume} = \text{Length} \times \text{Depth} \times (\text{Width} + \text{Slope} \times \text{Depth})$$

Depending on the type of bottom, the side slope can vary from 1:1 in rock, to 1:8 in a very soft bottom Significant rock outcroppings in the Cape Fear channel could affect the volume and cost of dredging, but to obtain a rough estimate, a slope of 1 vertical to 5 horizontal was assumed. Thus, the equation becomes

$$V = \frac{LD\ (W + 1.5D)}{27} \quad .$$

Actual channel dimensions shown in Table 8 were then converted into cubic yards and subtracted from the volume required for the proposed 45-foot channel to obtain 20,333,417 cubic yards of additional dredging

TABLE 8

Cape Fear Channel Dimensions

05′

34° 00′

CAPE FEAR RIVER CHANNEL DEPTHS

CORPS OF ENGINEERS REPORT OF FEB. 1, 1979 AND SURVEYS TO JUNE 1979

CONTROLLING DEPTHS FROM SEAWARD IN FEET AT MEAN LOW WATER (MLW)						PROJECT DIMENSIONS		
NAME OF CHANNEL	LEFT OUTSIDE QUARTER	LEFT INSIDE QUARTER	RIGHT INSIDE QUARTER	RIGHT OUTSIDE QUARTER	DATE OF SURVEY	WIDTH (FEET)	LENGTH (NAUT. MILES)	DEPTH MLW (FEET)
BALDHEAD SHOAL	A35.5	37.5	38.0	35.5	1-79	500	3.0	40
SMITH ISLAND	28.0	38.5	39.5	A37.0	3-79	500	0.8	40
BALDHEAD CASWELL	A38.5	40.0	40.0	A38.5	8-78	500	0.3	40
SOUTHPORT CHANNEL	40.0	40.0	40.0	A38.5	9-78	500	0.9	40
BATTERY ISLAND CHANNEL	40.0	40.0	40.0	A34.0	9-78	500	0.4	40
LOWER SWASH	A38.0	40.0	40.0	A34.5	8-78	400	1.4	38
SNOWS MARSH	A35.0	38.0	34.0	A34.0	1-79	400	2.0	38
HORSESHOE SHOAL	30.0	35.5	38.5	38.0	8-78,8-79	400	1.0	38
REAVES POINT	A38.5	38.0	37.5	A38.5	1-79	400	1.0	38
LOWER MIDNIGHT	35.0	38.0	38.0	A35.5	8-79	400	1.5	38
UPPER MIDNIGHT	A34.5	37.0	37.5	A35.0	1-79	400	2.3	38
LOWER LILLIPUT	A38.0	38.0	37.0	A32.5	1-79	400	1.7	38
UPPER LILLIPUT	37.5	37.5	37.0	A30.0	1-79	400	1.7	38
KEG ISLAND	A38.5	38.0	38.0	A31.0	7-78	400	1.3	38
BIG ISLAND LOWER	A37.5	38.0	38.0	A30.0	7-78	400	0.7	38
BIG ISLAND UPPER	A37.5	38.0	38.0	A34.0	7-78	400	0.4	38
LOWER BRUNSWICK	A20.5	36.5	38.0	A35.0	7-78	400	1.4	38
UPPER BRUNSWICK	A21.5	38.0	38.0	A33.0	7-78	400	0.8	38
FOURTH EAST JETTY	A33.0	38.0	38.0	A38.0	11-78	400	1.2	38
BETWEEN CHANNEL	A32.5	38.0	36.5	A33.5	1-79	400-600	0.7	38
ANCHORAGE BASIN	A25.0	31.5	32.5	A27.5	1-79	800-1100	1.1	38
THENCE TO TURNING BASIN	A28.0	34.0	35.0	A27.0	3-78	300-400	0.9	32
TURNING BASIN	A25.5	28.0	32.0	A28.5	3-78	800	0.5	32
CHANNEL THRU TURNING BASIN	A30.0	33.0	32.0	A28.5	3-78	400	0.5	32
THENCE TO HILTON BRIDGE	A28.5	30.0	30.0	A29.0	4-78	300	0.5	32
THENCE TO UPPER TURNING BASIN	25.0	25.0	25.0	A18.5	4-78	200	1.0	25
UPPER TURNING BASIN	25.0	25.0	24.5	A18.5	4-78	700	0.1	25
THENCE TO END OF PROJECT	A11.0	14.0	18.0	A17.5	4-78	200	0.3	25

A. ALONG EDGE OF CHANNEL.

NOTE-CONSULT THE CORPS OF ENGINEERS FOR CHANGES SUBSEQUENT TO THE ABOVE INFORMATION

PRODUCED BY COMPUTER ASSISTED METHODS

Source: National Oceanic and Atmospheric Administration, Cape Fear River Chart No. 11537, 1979.

required.

To obtain a rough approximation of dredging costs, the dredging volume can be calculated by multiplying by a unit cost. Interviews with dredging engineers in the Wilmington office of the U.S. Army Corps of Engineers[1] indicated that, because dredge spoil areas are almost nonexistent, disposal of any material from the Cape Fear River would probably have to take place at least three miles out in the ocean. As a result, unit costs could vary from $2 per cubic yard near the river mouth to as much as $12 per cubic yard in the upper reaches of the river where the round trip haul distance would be about 50 miles. The assumed average unit cost of $8 per cubic yard produced a dredging cost of $162,667,336. To this figure must be added an allowance for annual maintenance dredging. For purposes of this study two percent of the capital cost of dredging, or $3,253,347, was assumed to represent a reasonable yearly allowance for maintenance dredging.

Reaching any judgments concerning the viability of the WBSD design concept would require much more detailed information on costs as well as economic, social, and environmental impacts. Nevertheless, it appears that, if preliminary cost estimates are reasonable, the cost differential ($5.6 million) between WBSD vessels and conventional ships would be virtually offset by the dredging costs. Vessel and dredging costs have been assembled in Table 9 and discounted at 10% annually to produce a net discounted present value analysis. A schedule of WBSD ship purchases beginning with three vessels in 1984 (Column 3) would generate the 47 vessels needed to transport 37 million tons of export coal estimated for 1990. Dredging costs were programmed in a similar manner. The analysis indicated that the additional cost of the 47 WBSD vessels could be recouped in six years when measured against dredging costs foregone.

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[1]Personal interview, Wilmington, N.C. June 22, 1982.

TABLE 9

Net Discounted Present Value Analysis

(Cost in $ million)

(1)	(2) Year	(3) No of WBSD ships	(4) Extra Cost of WBSD Ships	(5) Dredging Costs: Capital	(6) Dredging Costs: Maint.	(7) Dredging Costs: Total	(8) Net Cash Flow	(9) P/F @ 10%	(10) Present Worth of Net Cash Flow	(11) Cumulative Balance
0	1983	0	0	50	-	50	-50	1.0	-50.0	-50.0
1	1984	3	16.8	50	3.2	53.2	-36.4	.9091	-33.1	-83.1
2	1985	8	44.8	63	3.2	66.2	-21.4	.8264	-17.7	-100.8
3	1986	8	44.8	-	3.2	3.2	+41.6	.7513	+31.3	-69.5
4	1987	8	44.8	-	3.2	3.2	+41.6	.6830	+28.4	-41.1
5	1988	10	44.8	-	3.2	3.2	+52.8	.6209	+32.8	- 8.3
6	1989	10	56.0	-	3.2	3.2	+52.8	.5645	+29.8	+21.5
7	1990	-	56.0	-	3.2	3.2	- 1.6	.5132	- 1.6	+19.9

7.0 Findings and Conclusions

The possibility of utilizing alternative technologies to transport and handle steam coal for export was assessed in CEIP Report No. 12. One of the most promising proposals suggested in this report was the concept of using wide beam, shallow draft ships to serve planned coal terminals along the Cape Fear River rather than require additional dredging to accomodate larger conventional vessels.

Following a determination of future trends in dry bulk carrying ship sizes and regional demands for bulk commodities, the potential role of WBSD vessels for coal export from terminals along the lower reaches of the river was examined. Existing WBSD ship technology, with particular emphasis on a recent Maritime Administration (MARAD) study of large shallow draft bulk carrier technology, was reviewed. Competing alternatives, including conventional bulk carrier systems, channel dredging, and offshore systems were also investigated. Finally, a 65,000 dwt. WBSD vessel was designed to satisfy the unique limitations of the Cape Fear River, and the resulting ship parameters were utilized to conduct a ship systems analysis.

The following items represent specific findings of the WBSD ship study:

- ° Despite the fact that ship size limitations of the U.S. Atlantic coast are approximately 80,000 dwt. at Hampton Roads and 60,000 dwt. at shallower ports, about half the world's coal fleet is presently 60,000 dwt. or larger.
- ° The use of wide beam, shallow draft carriers for coal export presents an opportunity to lower ocean transportation costs and relieve port congestion without requiring channel dredging.
- ° By lengthening and widening a ship without increasing its draft, its relative proportions are altered so the carrying capacity can be increased from 40 to 60 percent.

- The large beam of WBSD designs can present operational difficulties if channels are not wide enough or if shoreside cargo handling equipment does not have sufficient reach.
- Previous studies indicated that construction cost of a WBSD vessel is approximately 4 to 11 percent higher than a conventionally designed vessel of the same deadweight but greater draft.
- At constant draft, the Required Freight Rate (RFR), or cost per ton of owning and operating a ship, of the WBSD vessel is lower than the conventional vessel.
- In a limited depth channel, such as the Cape Fear River, several alternatives to the use of WBSD ships for coal export - shallow draft ship systems, channel and port dredging, and offshore deep water terminals - can be identified.
- A 65,000 dwt. WBSD collier with a 35-foot draft could safely navigate the 38 x 400-foot channel of the Cape Fear River from its mouth northward to the U.S. 17 highway bridge in Wilmington, but could not maneuver in the restricted channels north of this location.
- To handle the maximum potential 1985 and 1990 export coal demand or similar tonnages of other dry bulk commodities, on the lower Cape Fear River, the following number of vessels would be required:

Year	Annual Throughput (MTA)	Conventional Ships Annual	Conventional Ships Daily	WBSD Ships Annual	WBSD Ships Daily
1985	25	625	1.7	384	1.1
1990	37	925	2.5	569	1.6

- Exclusive use of a fleet of WBSD vessels in the U.S. - Northern Europe coal trade would require 32 ships by 1985 and 47 ships by 1990 to handle potential coal exports from the Cape Fear River region. Without a massive shipbuilding effort accompanied by the use of WBSD ships at other U.S. ports, production of any significant number of new ships by 1985 would not be realistic.
- Channel dredging, the most realistic alternative to a WBSD vessel concept along the river, would require a 45-foot channel to handle conventional 65,000 dwt. colliers.
- Cost estimates for deepening the Cape Fear River from 38 to 45 feet total approximately $163 million plus $3.2 million annually for maintenance dredging.
- A new discounted present value analysis indicates that by 1990

the additional cost of constructing the required WBSD vessels would be offset by the cost saved by not dredging the channel.

The foregoing list of findings led to the following general conclusions regarding the feasibility of using wide beam, shallow draft bulk carriers to export coal from the Cape Fear River region:

- ° While softness in the current world market for U.S. coal will probably lead to delays or cancellations in the construction of new export terminals, the long term outlook for export coal demand remains optimistic. Most forecasts still call for significant increases by 1990 and dramatic increases by the year 2000. It is anticipated that at worst none of the five companies planning new facilities along the river will build during the 1980's and at best several will build terminals with reduced throughputs or extended time frames for export projections.
- ° If new terminals are constructed, they will be at a competitive disadvantage with other Atlantic coast coal ports with deeper channels. This disadvantage could be offset by one of the following actions:

  1) Remove all coal ships from the Cape Fear River by constructing an offshore terminal near Pender County to handle deep-draft bulk carriers;
  2) Dredge the river to 45 feet; or
  3) Employ a fleet of WBSD vessels without deepening the channel.
- ° An offshore, deepwater terminal would require massive injections of private capital, long term coal contracts, new (currently available) handling and loading technology, and extensive permitting procedures to ensure environmental safeguards. Similarly, dredging appears to be an unattractive option because of high costs, lack of disposal sites, long lead time for approvals, and virtually insurmountable environmental concerns. Subject to precise engineering and economic feasibility studies, the WBSD vessel concept would indeed offer a challenging option for the marine transport of any future coal exports from the lower Cape Fear. The technology is available, but only extremely careful planning and long term commitments of interested parties could make it a reality.

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GLOSSARY

Abbreviations

dwt - deadweight tons
OBO - ore-bulk-oil carrier
WBSD - wide beam, shallow draft (vessel)
VLCC - very large crude carrier
ULCC - ultra large crude carrier
Cb - block coefficient
RFR - required freight rate

Terms

draft - vertical distance from waterline to bottom of keel
depth - vertical distance from main watertight deck to bottom of keel
Required Freight Rate - average annual cost divided by amount of cargo carried annually
collier - a dry bulk carrier engaged in the coal trade
block coefficient - a coefficient of fineness which expresses the relationship between the volume of displacement and a block having the length, breadth, and draft of the vessel.
displacement - the weight of water displaced by a floating object
beam - width of ship
deadweight tonnage - the number of long tons of cargo, stores, and lumber fuel which a vessel can carry

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